

THIS OPINION WAS NOT WRITTEN FOR PUBLICATION

The opinion in support of the decision being entered today (1) was not written for publication in a law journal and (2) is not binding precedent of the Board.

Paper No. 17

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte JOSEPH S. SHOR,
ANTHONY E. KURTZ,
and DAVID GOLDSTEIN

Appeal No. 96-4052
Application 08/198,511¹

ON BRIEF

Before URYNOWICZ, BARRETT, and FLEMING, Administrative Patent Judges.

BARRETT, Administrative Patent Judge.

DECISION ON APPEAL

¹ Application for patent filed February 17, 1994, entitled "Method For Etching Of Silicon Carbide Semiconductor Using Selective Etching of Different Conductivity Types," which is a continuation of Application 07/777,157, filed October 16, 1991, now abandoned.

This is a decision on appeal under 35 U.S.C. § 134 from the final rejection of claims 31, 33-46, 48, and 49.

We affirm-in-part.

BACKGROUND

The disclosed invention is directed to a method for photoelectrochemically etching silicon carbide (SiC), and particularly, to an etching method using selective etching of different conductivity types of SiC.

Claim 31 is reproduced below.

31. A method for fabricating a semiconductor by selectively etching, said method comprising the steps of:

providing a substrate;

forming a first semiconducting layer on said substrate, said first semiconducting layer comprising p-type silicon carbide, and requiring a first voltage for charge transport at a surface of said layer in a given electrolytic etching solution;

forming a second semiconductor layer on said first layer, said second layer comprising n-type silicon carbide, and requiring a second voltage for charge transport at a surface of said second layer in said given electrolytic etching solution which is lower than said first voltage;

placing said substrate into said given electrolytic etching solution;

applying a bias voltage to said second semiconductor layer which is between said first and second voltages;
and

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creating charge holes in selected regions of said surface of said second semiconductor layer to promote etching of said selected regions to form said semiconductor, whereby said etching automatically stops when regions of said first semiconductor layer under said selected regions become exposed.

The examiner relies on appellants' admission that alpha silicon carbide ("SiC) and beta silicon carbide (\$-SiC) were known (specification, page 5, lines 8-11) and that titanium contacts on SiC were known (specification, page 14, lines 20-25) and on the following prior art references:

| | | | |
|-------|--------------------------|-----------|-----------------|
| 1963 | Chang | 3,078,219 | February 19, |
| 1983 | Kohl et al. (Kohl) | 4,369,099 | January 18, |
| 1983 | Forrest et al. (Forrest) | 4,414,066 | November 8, |
| 1991 | Ajika et al. (Ajika) | 5,049,975 | September 17, |
| 1993 | Steitz et al. (Steitz) | 5,182,420 | January 26, |
| | | | (filed April 9, |
| 1990) | | | |

Claims 31, 33-35, 39-46, 48, and 49 stand rejected under 35 U.S.C. § 103 as being unpatentable over Forrest, Kohl, Chang, and the admission that "-SiC and \$-SiC were known.

Claims 31, 33-46, 48, and 49 stand rejected under 35 U.S.C. § 103 as being unpatentable over Forrest, Kohl, Chang, and the admission that "-SiC and \$-SiC were known,

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further in view of the admission that titanium contacts on SiC were known and Steitz and Ajika as to the contacts recited in claims 36-38. The rejection would have been clearer if it were limited to claims 36-38 over the additional prior art of titanium contacts, Steitz, and Ajika.

We refer to the Final Rejection (Paper No. 9) (pages referred to as "FR__") and the Examiner's Answer (Paper No. 16) (pages referred to as "EA__") for a statement of the examiner's position and to the Brief (Paper No. 15) (pages referred to as "Br__") for a statement of appellants' position thereagainst.

OPINION

Grouping of claims

Appellants set forth five groupings of claims (Br3):

- (1) claims 31, 33, and 34 are said to stand or fall together;
- (2) claims 35-39 are said to stand or fall together;
- (3) claims 40-44 and 46 are said to stand or fall together;
- (4) claim 45 is said to stand or fall alone; and (5) claims 48 and 49 are said to stand or fall together. Although appellants state that claims within each group stand or fall together (which means that the patentability of a group of

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claims will be determined on the basis of a single claim selected from the group), appellants have proceeded to argue the separate patentability of many of the claims within a group individually. We address the argued claims separately.

Level of ordinary skill in the art

We find the knowledge and level of ordinary skill in the art to be demonstrated by the references. See In re Oelrich, 579 F.2d 86, 91, 198 USPQ 210, 214 (CCPA 1978) ("the PTO usually must evaluate both the scope and content of the prior art and the level of ordinary skill solely on the cold words of the literature"); In re GPAC, Inc., 57 F.3d 1573, 1579, 35 USPQ2d 1116, 1121 (Fed. Cir. 1995) (the Board did not err in adopting the approach that the level of skill in the art was best determined by the references of record). In addition, those of ordinary skill in the art must be presumed to know something about the art apart from what the references expressly disclose. In re Jacoby, 309 F.2d 513, 516, 135 USPQ 317, 319 (CCPA 1962).

Claims 31, 33, and 34

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Forrest discloses a process for photoelectrochemically etching n-type compound semiconductors. The only difference argued between Forrest and the subject matter of claim 31 is claim 31's limitation that the semiconductor layers are silicon carbide. Forrest states (col. 2, lines 40-46): "The electrochemical photoetching procedure applies to a certain class of semiconductors, namely compound semiconductors including III-V and II-VI compound semiconductors. Typical semiconductors are CdS, CdSe, HgCdTe, GaP, GaAs, AlAs, AlP, AlSb, InSb, InAs, InP, GaInAs, GaInP, GaInAsP, GaAlP and GaAlAs." The listed "typical semiconductors" are all III-V or II-VI compound semiconductors.

Appellants argue (Br4): "Careful reading of the Forrest et al. process, as described in column 2, lines 40-45, shows that the Forrest et al. process applies only to a certain class of semiconductors this class being III-V and II-VI compound semiconductors. . . . Applicant submits that while SiC is arguably considered a compound semiconductor, it is certainly not a III-V or II-VI compound semiconductor."

The examiner finds that Chang "teaches that SiC can also be electrochemically etched" (FR2; EA3) and concludes (FR2-3;

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EA3): "Forrest illustrates the wide range of semiconductors that can be used, but does not specifically mention SiC, however, with Chang's teachings, it would [have] be[en] obvious to etch SiC (including any of the conventional crystal forms) in the manner of Forrest (and also to use a light mask, as taught by Kohl.)" The examiner admits that "Forrest does not specifically list SiC" (EA4), but states that "Forrest says 'compound semiconductor' (of which SiC is one) and gives examples" (EA4-5).

We agree with the examiner's position. In Forrest's statement that "[t]he electrochemical photoetching procedure applies to a certain class of semiconductors, namely compound semiconductors including III-V and II-VI compound semiconductors" (emphasis added) (col. 2, lines 40-43), the underlined phrase indicates that the procedure is directed to "compound semiconductor" including, but not limited to, III-V and II-VI compound semiconductors. For example, a statement "a class of persons, namely engineers including engineers named Bob" means that the group positively includes engineers named Bob, but may include other engineers with other names. Thus, we do not agree with appellants' interpretation of

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Forrest. One of ordinary skill in the art would have read Forrest to indicate that the technique applies generally to compound semiconductors (as opposed to elemental semiconductors such as silicon or germanium), and that III-V and II-VI compound semiconductors are expressly named because they constitute the most important types of compound semiconductor for device manufacture. SiC is without doubt a compound semiconductor. See Sze, Physics of Semiconductor Devices (2d ed., John Wiley & Sons, 1981), pages 690, 696, 848 (Appendix F), and 849 (Appendix G) (copy attached). One of ordinary skill in the art seeking to etch SiC (the problem to be solved) would have been motivated to apply the selective conductivity photoelectrochemical etching technique described in Forrest because Forrest teaches that the process is applicable to compound semiconductors in general.

Appellants' arguments are directed to the lack of express teaching of SiC in Forrest. However, obviousness is determined through the eyes of one of ordinary skill in the art and takes into account what one of ordinary skill would have known. One of ordinary skill would have known the SiC is

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a compound semiconductor and, therefore, that Forrest encompasses photoelectrochemical etching of SiC.

It is true, as argued by appellants (Br5-6), that Chang is directed to an electrolytic process, not a photoelectrochemical process. Chang does not use light to create charge holes in selected regions of the surface, as claimed. However, Chang is applied only to show that it was known to etch SiC, which fact does not appear to be in question. Chang appears superfluous to the rejection. If Forrest did not suggest applying the technique to all compound semiconductors, then it would be difficult to find motivation in Chang for using the process in Forrest.

Kohl is not needed for the rejection of claim 31; therefore, appellants' arguments regarding Kohl (Br5) are not persuasive. Kohl is used for its teaching of a mask in a photoelectrochemical etching process, but a mask is not recited in claim 31. Claim 31 recites "creating charge holes in selected regions of said surface," but does not recite using a mask to provide selected regions. Forrest discloses using "lenses to collimate the light and concentrate the light

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on the area of the surface where it is required" (col. 7, lines 22-24), which meets claim 31.

The rejection of claim 31 is sustained. Appellants have not argued the separate patentability of claims 33 and 34. Thus, the rejection of claims 33 and 34 is also sustained.

Claims 35-39

This group of claims is directed to the contact. Forrest discloses "applying a potential to the compound semiconductor" (col. 1, lines 51-52), but does not describe an ohmic contact on the top layer or that the contact is removed after etching.

The examiner states that "[o]bviously a contact is needed for electrochemical etching, and removing it afterward is at least obvious" (FR2; EA3). Appellants argue that Forrest does not disclose forming contacts on the compound semiconductor and "[h]ence, we do not know if the contacts used in the Forrest et al. process are ohmic contacts (Applicant's claim 35), . . . or whether the contacts are removed after the etching process (Applicant's claim 39)" (Br7).

We agree with the examiner. A contact is required to attach the electrical wire to the semiconductor. Kohl, which is a photoelectrochemical etching process for p-type

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semiconductor compounds, discloses that the electrical contact may be the mask (col. 5, lines 59-60) or "ohmic contacts formed by the electrodeposition of gold" (col. 6, lines 17-18). Since the contact is required only for etching, one of ordinary skill in the art would have known to remove it after etching. For these reasons, we sustain the rejection of claims 35 and 39.

Claim 36 requires a contact made of layers of titanium (Ti), titanium nitride (TiN), and platinum (Pt). Claim 38 recites an additional layer of gold (Au). The examiner states that "it is also admitted (and obvious to use) that SiC is frequently contacted with Titanium, and Steitz teaches covering a titanium contact with layers of TiN, Pt, and Au, which would [have] be[en] obvious in etching SiC" (FR3; EA3). The specification states that "Ti or TiC, as an ohmic contact to n-type β -SiC, has been extensively discussed in the literature . . ." (specification, page 14, lines 20-22), which is taken as an admission that the teaching is in the prior art. Appellants state that only Ti or TiC was admitted, whereas the claims call for a compound layer of Ti/TiN/Pt (claim 36) or Ti/TiN/Pt/Au (claim 38) and that Steitz does not

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show contact between Ti and SiC. On this point we agree with appellants. The examiner has not shown the claimed contact structure on SiC. Nor has the examiner explained why one of ordinary skill in the art would have been motivated to use the contact structure of Steitz. Appellants use the contact structure to provide stability to the contact (e.g., specification, page 13, lines 31-34), whereas Steitz discloses that the plurality of metals enhances bonding (col. 3, lines 41-46). Thus, we see no motivation to combine the teachings of Steitz with Forrest. The rejection of claims 36 and 38 is reversed. Since claim 37 depends on claim 36, the rejection of claim 37 is also reversed.

Claims 40-44 and 46

This group of claims is directed to masking. The examiner states that "Kohl et al uses a mask for the light in photo-electrochemical etching" (FR2; EA3) and concludes that it would have been obvious "to use a light mask, as taught by Kohl" (FR3; EA3).

Appellants argue that Kohl is directed to III-V and II-VI semiconductors and that "[t]he Forrest et al. patent fails to disclose a masking process for use with a SiC semiconducting

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material" (Br10). Appellants argue that Kohl involves photoelectrochemical etching of p-type semiconductor compounds, whereas claim 31 recites an n-type material (Br5).

Kohl discloses a photoelectrochemical etching process where "[a] mask 27 may be used on the surface of the semiconductor to define the area illuminated by radiation" (col. 5, lines 54-56). Kohl discloses that "[t]he mask metal may be used as the electrical contact to the semiconductor" (col. 5, lines 59-60). The mask in Kohl would have suggested the use of such a mask in Forrest since both are photoelectrochemical etching processes. The difference in conductivity types of the material being etched, p-type in Kohl versus n-type in Forrest, does not negate the teaching of using a mask on the material. It is also considered notoriously well known in the semiconductor manufacturing art to used mask layers to selectively control the area exposed. The rejection of claims 40 and 41 is sustained.

Ultraviolet (UV) light is recited in claims 42 and 46. These claims are not argued by appellants and we will not address issues not argued in the brief. See 37 CFR § 1.192(c)(8)(iv) (errors must be addressed in brief). Cf.

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In re Baxter Travenol Labs., 952 F.2d 388, 391,
21 USPQ2d 1281, 1285 (Fed. Cir. 1991) ("It is not the function
of this court to examine the claims in greater detail than
argued by an appellant, looking for nonobvious distinctions
over the prior art."); In re Wiechert, 370 F.2d 927, 936,
152 USPQ 247, 254 (CCPA 1967) ("This court has uniformly
followed the sound rule that an issue raised below which is
not argued in this court, even if it has been properly brought
here by a reason of appeal, is regarded as abandoned and will
not be considered. It is our function as a court to decide
disputed issues, not to create them."). The rejection of
claims 42 and 46 is sustained.

Appellants argue that "[t]he masking material, as taught
by Kohl et al. (column 5, lines 56-59), comprises noble
metals, and hence does not include silicon nitride (which is
not a metal) and chromium (which is not a noble metal) as are
recited in Applicant's claim 43" (Br10). Applicant argues
that "it would not have been obvious to 1) use materials that
were not even suggested by Kohl et al. (silicon nitride and
chromium) as masking agents" (Br10-11). This argument is not
persuasive. Claim 43 recites that "said masking material is

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selected from a group consisting of silicon nitride, chromium and platinum." Since Kohl discloses platinum as a mask material (col. 5, lines 57-59), it meets claim 43. Kohl need not teach every member of the group. The rejection of claim 43 is sustained.

Appellants argue that "claim 44 of Applicant's invention is directed towards a process that does not require a masking material to be deposited on the substrate" (Br10) and the use of a mask which does not contact the substrate is not suggested by Forrest as modified by Kohl. The examiner offers no response. However, we note that claim 44 does not exclude a mask deposited on the substrate; "imaging" still occurs even though the mask is on the substrate. The rejection of claim 44 is sustained.

Claim 45

Appellants argue that claim 45 requires masking by focusing a microscopic laser beam and that "[t]he Examiner fails to propose how Forrest et al. can be modified to arrive at the presently recited invention of claim 45" (Br11). The examiner offers no response. Nevertheless, Forrest discloses that "[a] tungsten light bulb is used and lenses to collimate

the light and concentrate the light on the area of the surface where it is required" (col. 7, lines 22-24), which teaches masking by focusing of the light source. Kohl teaches that "[t]he light source may have a broad energy spectrum such as an incandescent bulb, a limited energy spectrum such as a mercury lamp or a narrow spectrum such as a laser source" (col. 5, lines 47-50). It would have been obvious to one having ordinary skill from Kohl to use a laser beam instead of the light bulb in Forrest. The rejection of claim 45 is sustained.

Claims 48 and 49

Appellants argue that Forrest fails to disclose forming and removing an oxidized layer over the n-type SiC layer as recited in claims 48 and 49 and "[t]he Examiner fails to propose how Forrest et al. can be modified to arrive at the presently recited invention of claims 48 and 49" (Br12). The examiner offers no response and we do not find the limitation in the references. It is the examiner's duty to establish a prima facie case of obviousness. The rejection of claims 48 and 49 is reversed.

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CONCLUSION

The rejections of claims 31, 33-35, and 39-46 are sustained.

The rejections of claims 36-38, 48, and 49 are reversed.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 CFR § 1.136(a).

AFFIRMED-IN-PART

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| STANLEY M. URYNOWICZ, JR. |) | |
| Administrative Patent Judge |) | |
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| |) | BOARD OF PATENT |
| LEE E. BARRETT |) | APPEALS |
| Administrative Patent Judge |) | AND |
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| |) | |
| MICHAEL R. FLEMING |) | |
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